G.E.M.S

Gym Equipment Monitoring System

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Goals

Project Objective

- Develop an **AI-powered gym equipment monitoring system** that detects when equipment is in use and updates a web interface in real time.
- **Reduce user frustration** by providing live updates on gym equipment availability.
- Improve **gym efficiency** by offering gym owners insights into equipment usage patterns.

Background & Motivation

- Many gym-goers struggle to find available equipment, leading to **wasted time** and **inefficient workouts**.
- Gym staff **lack real-time data** on which machines are used the most or require maintenance.
- AI-based detection can **automate tracking** without the need for additional staff monitoring.

Key Features of the System

- **Real-time detection** using machine learning (YOLOv5).
- **Automated status updates** via a MySQL database.
- **Web-based user interface** for gym members to check equipment availability.
- **Data insights** for gym owners on peak usage times

Intellectual Merits

Innovative Use of AI in Gym Management

- Integrates **computer vision** and **database management** to create a real-time monitoring system.
- Uses **YOLOv5**, a state-of-the-art object detection model, to identify gym equipment usage.

Unique Contributions & Novelty

- Unlike traditional gym monitoring systems (manual check-ins or RFID tracking), this project provides:
  - **Automated, AI-driven tracking** with minimal human intervention.
  - **Live status updates** on gym equipment through a web platform.
  - **Cooldown logic** to prevent false detections and improve accuracy.

Advanced Machine Learning & Computer Vision

- Utilizes a **pre-trained YOLOv5 model**, fine-tuned with **custom gym equipment images** for high detection accuracy.
- Implements a **multi-class recognition system**, identifying both equipment and user presence.
- Runs on **CUDA-enabled GPUs** for real-time video processing.

Intellectual Merits Continued

Impact on Human-Computer Interaction

- Provides an **intuitive, user-friendly experience** for gym members via a web interface.
- Demonstrates how **AI can seamlessly integrate into public and commercial spaces** to enhance user convenience.

Scalability & Future Applications

- The system can be adapted for various industries, such as:
  - Corporate Environments
    1. Conference Rooms, offices, etc. (availability)
  - Entertainment/Recreation
    1. Amusement Parks (foot traffic)
  - Retail
    1. Supermarkets (foot traffic)

Broader Impact

Impact on Gym Users

- **Live Equipment Status**:
  - Users can check which equipment is occupied during workout and before heading to the gym.
  - Reduces frustration and waiting times.
- **Enhanced Workout Planning**:
  - Helps users plan their workout based on available equipment.
  - Promotes better time management for gym-goers.

Benefits for Gym Owners & Staff

- **Optimized Equipment Usage**:
  - Data analytics can help gym owners understand peak usage times.
  - Identifies underutilized equipment, allowing for better resource allocation.
- **Maintenance Scheduling**:
  - Equipment usage logs help predict wear and tear, reducing unexpected breakdowns.

Broader Impact Continued

Broader Societal Contributions

- **Encouraging Fitness & Healthy Lifestyles**:
  - Streamlining gym accessibility could promote more consistent exercise habits.
  - Reduces frustration that may deter people from working out.
- **Scalability Beyond Gyms**:
  - The detection model can be adapted for other industries:
  - Corporate Environments
    - Conference Rooms, offices, etc. (availability)
  - Entertainment/Recreation
    - Amusement Parks (foot traffic)
  - Retail
    - Supermarkets (foot traffic)

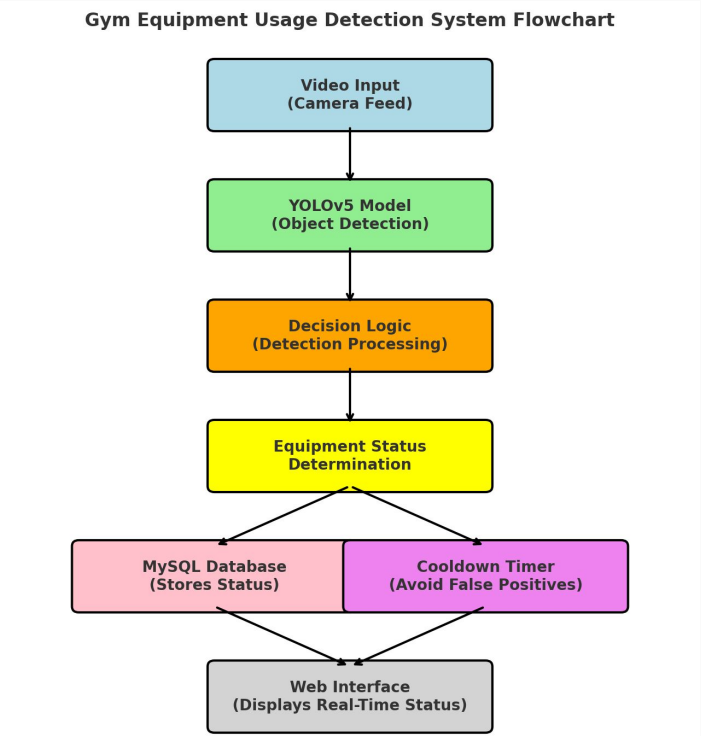
Technological Advancements

- **Real-Time AI in Everyday Life**:
  - Demonstrates how AI can enhance public and commercial spaces.
- **Data-Driven Decision Making**:
  - Insights from collected data can lead to smarter facility management.

Design Specifications

- **System Overview**:
  - **Camera Feed → YOLOv5 Model → SQL Database → Web Interface**
- **Design Diagram**:
  - A **flowchart** showcasing data movement between system components on next slide.
- **Implementation Details**:
  - Detection model runs on **CUDA-enabled GPUs** for efficiency.
  - Web UI built with **Flask and SQL** for equipment monitoring.

Flow Chart


Gym Equipment Usage Detection System Flowchart
Video Input
(Camera Feed)
YOLOv5 Model
(Object Detection)
Decision Logic
(Detection Processing)
Equipment Status
Determination
MySQL Database
(Stores Status)
Cooldown Timer
(Avoid False Positives)
Web Interface
(Displays Real-Time Status)

Technologies Used

- **Machine Learning**: YOLOv5 for real-time detection.
- **Database**: MySQL for storing equipment usage data.
- **Backend**: Python (Flask) for processing detections.
- **Frontend**: HTML/CSS for user-friendly interface.
- **Hardware**: Camera setup for real-time monitoring.
- **Detection Software**:
  - Runs the **YOLOv5 model** to detect gym equipment usage.
  - **Automatically updates the database** when equipment status changes (e.g., "in use" → "available").
  - Uses a **cooldown mechanism** to reduce false detections.

Milestones

Challenge	Solution
False detections due to movement or lighting	Implemented a **cooldown timer** mechanism to prevent rapid status changes.
Database synchronization issues	Optimized **MySQL queries and indexing** to ensure real-time updates.
Slow detection speed on CPU	Used **GPU acceleration (CUDA)** to speed up YOLOv5 inference.
Difficulty in differentiating equipment	Trained YOLOv5 on **custom-labeled datasets** with diverse gym conditions.
Varying lighting conditions in gyms	Collected **dataset images from different lighting environments** to improve model robustness.
Web interface delays in displaying updated statuses	Implemented **AJAX polling** to refresh equipment status dynamically without full page reloads.

Results Achieved

YOLOv5 Model Successfully Trained

- The detection model was trained with **custom-labeled images** of gym equipment.
- Achieved **high accuracy** in detecting equipment and user presence.

Real-Time Detection Implemented

- Integrated **YOLOv5 with OpenCV** to process live camera feeds.
- Detection system runs **efficiently on CUDA-enabled GPUs** for faster inference.

Database Integration Completed

- MySQL database **stores and updates equipment status** dynamically.
- Detection results are automatically **logged and updated** in real time.

Results Achieved Continued

Web Interface Development - In Progress

- Basic **HTML/CSS layout created**, connected to the backend.
- Need to refine **UI design and AJAX polling** for real-time status updates.
- Still working on **user accessibility features** for gym members.

Remaining Tasks:

- Complete **frontend integration** and polish the UI.
- Conduct **full-system testing** to ensure stability.
- Deploy and optimize the final version.

Challenges & Solutions

Challenge	Solution
False Detections (misidentifying equipment usage)	Implemented a **cooldown timer** to prevent rapid status changes and reduce false positives.
Database Synchronization Issues	Optimized **MySQL queries** and added **indexed tables** for faster updates and retrieval.
Slow Detection Speed on CPU	Moved processing to **CUDA-enabled GPUs**, significantly improving YOLOv5 inference speed.
Varying Lighting Conditions	Trained the model on **diverse lighting environments** and applied **image preprocessing** to enhance consisten
Data Collection Challenges	Gathered a **larger dataset** with more variations, including different gym setups and angles, to improve detection.
Accuracy of the Model	Fine-tuned YOLOv5 with **custom-labeled data** and used **data augmentation techniques** to enhance performance.

Test Plan and Results

- Strategy:
  - Component-level + full-system testing using gym footage (controlled scenarios). Focus on detection accuracy, consistency, and DB integration. Tested both normal and abnormal cases.
- Metrics:
  - Precision = correct detections / all detections (false positives)
  - Recall = correct detections / actual items (false negatives)

Category	Precision	Recall
Person Detection	79.6%	67.5%
Dumbbell Bench	88.5%	88.2%
Treadmill	90.0%	50.0%
Chest Bench	90.0%	100%

Summary of hours

Semester	Parker's Hours	Josh's Hours
Fall 2024	47	46
Spring 2025	50	51

References

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